INSTREAM FLOWS RESEARCH AND VALIDATION METHODOLOGY FRAMEWORK - 2016-2017

TEXAS STATE UNIVERSITY
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Department of Biology

GSA BBASC
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BAYLOR UNIVERSITY
1845
ENVIRONMENTAL SCIENCE

BIO-WEST

SAN ANTONIO RIVER AUTHORITY

OVERVIEW

- Funded - Texas Water Development Board
  - Via the SB3 BBASC process
  - 1st round – 2014-2015
  - 2nd round – 2016-2017
- Three major basins
  - **Guadalupe – San Antonio Basin**
  - Colorado – Lavaca Basin
  - Brazos Basin
- Project goals:
  - To enhance the understanding of flow-ecology relationships in the three major basins
  - To initiate the process for developing a methodology for testing established flow standards

ECOLOGICAL COMPONENTS

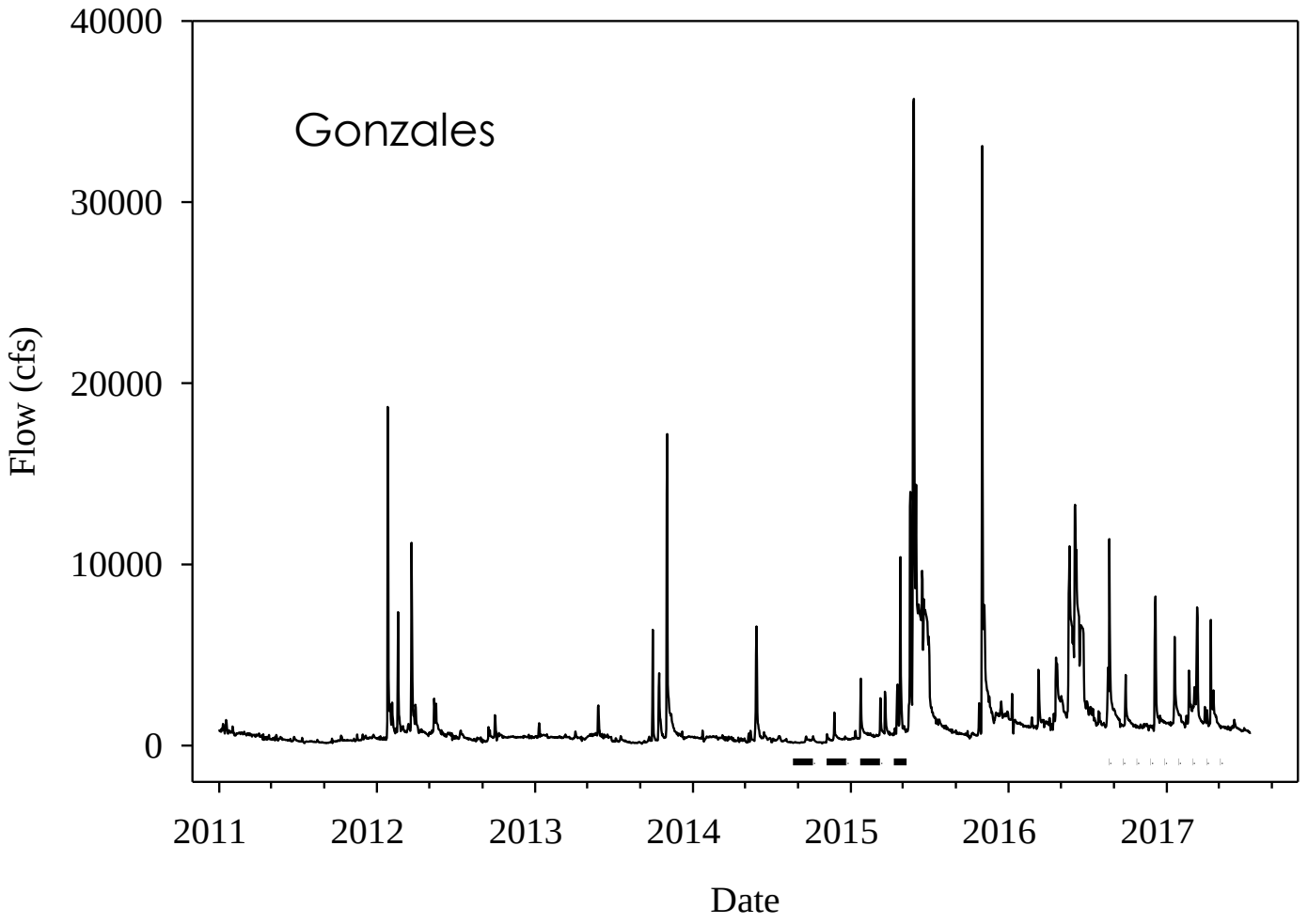
- Aquatic
- Floodplain Connectivity
- Riparian

SAMPLING ACTIVITIES AND RESULTS

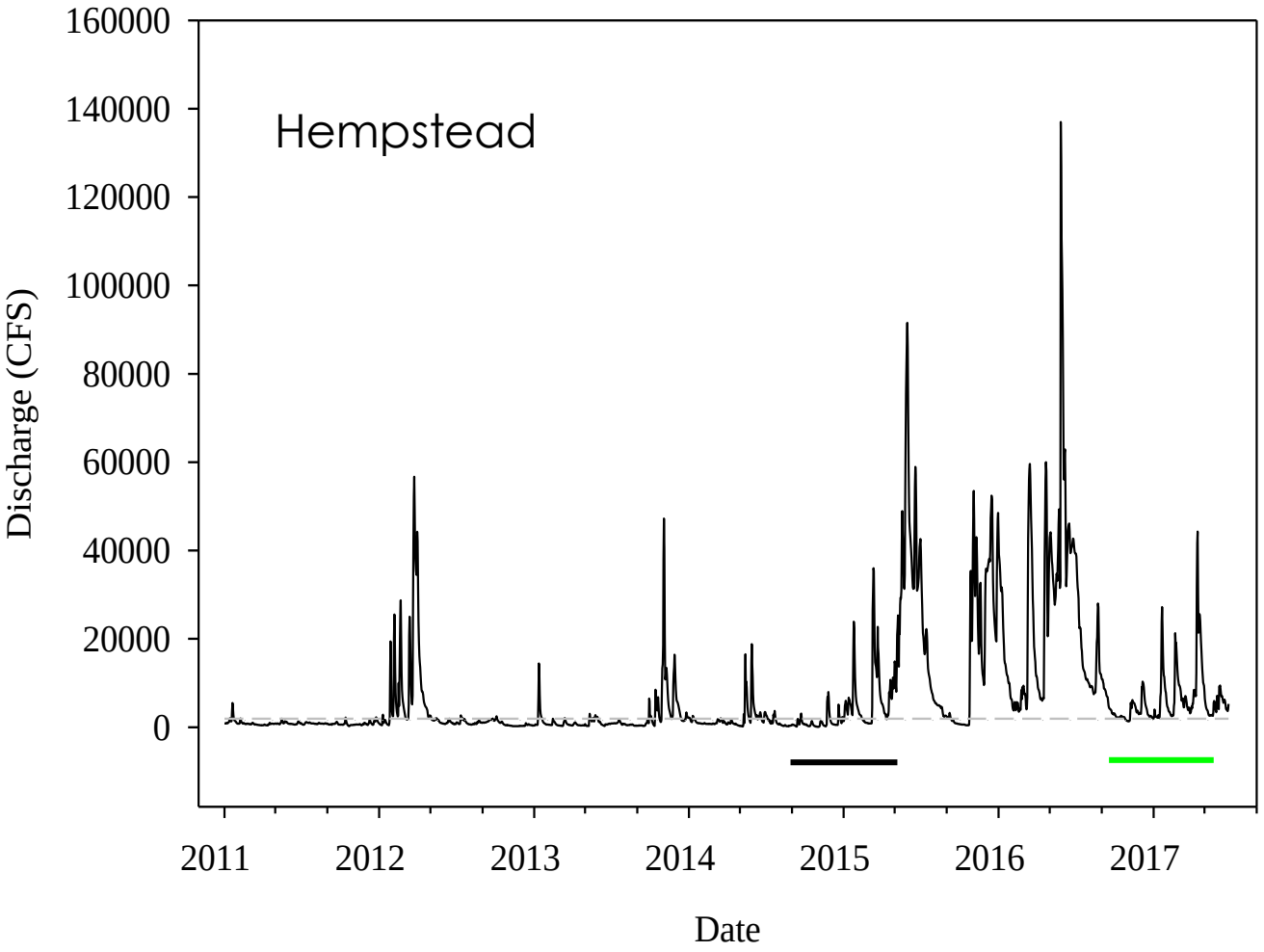
AQUATICS

- Dr. Timothy Bonner

LOWER GUADALUPE RIVER – GONZALES

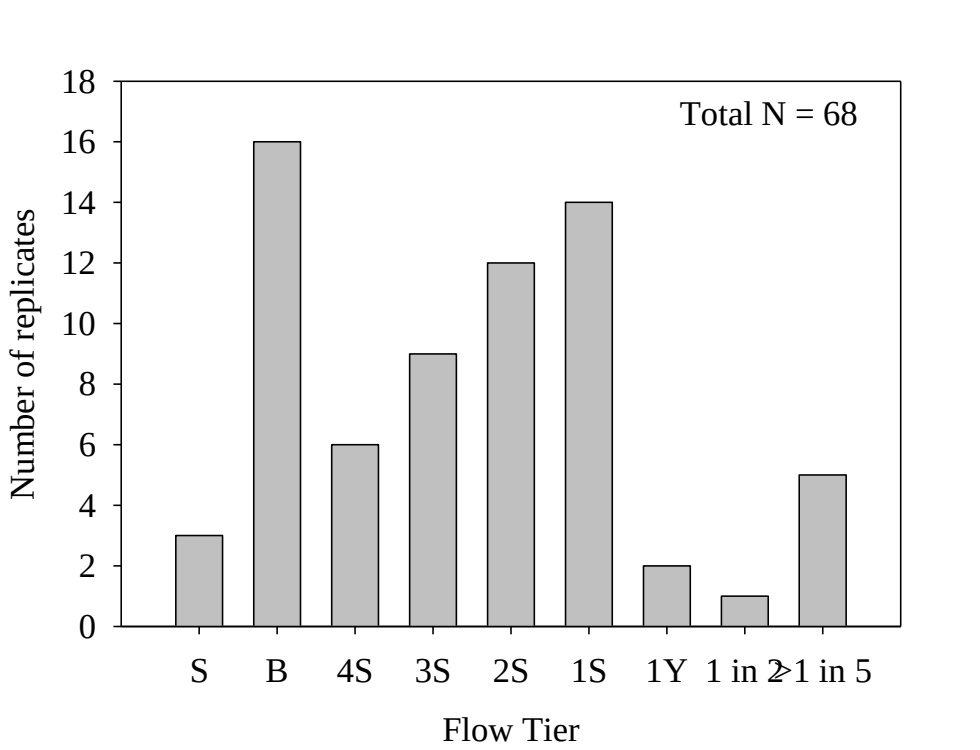


LOWER BRAZOS RIVER – HEMPSTEAD



GSA 2014 - 2017

- 40 fish species; 14,674 fishes
- 9 orders; 41,990 macroinvertebrates

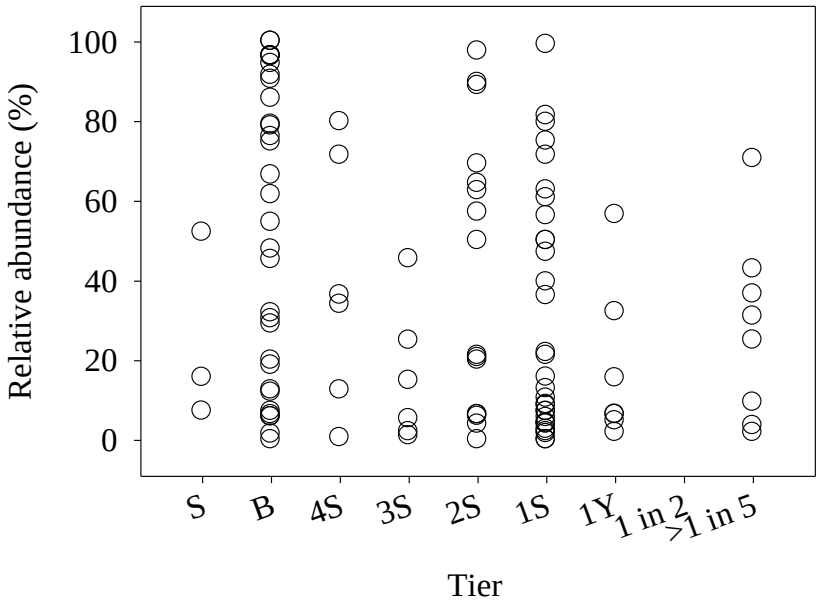


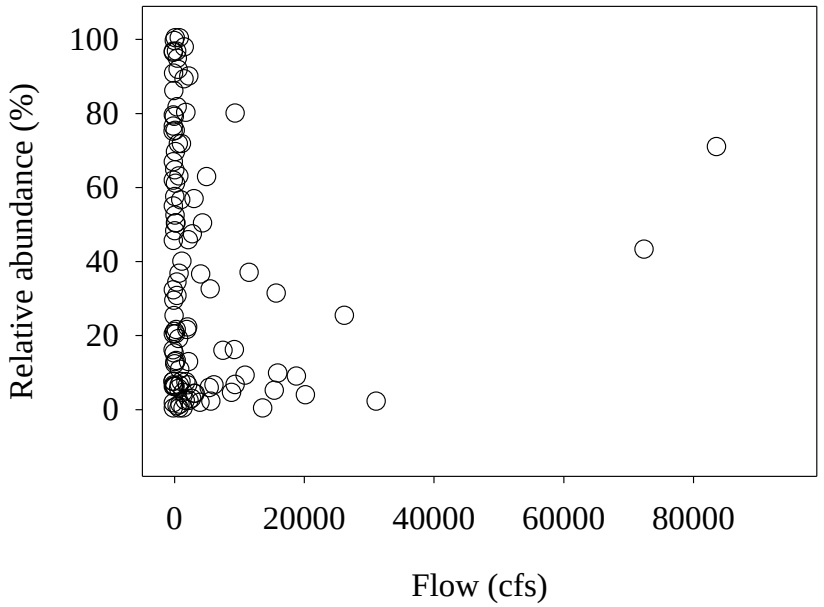
ALL BASINS 2014 - 2017

- Sampled habitats (N = 362, with 716 seine hauls)
  - 130 riffles
  - 153 runs
  - 56 backwaters
  - 23 pools
- Fish: 59 species; *N* = 43,349
- Aquatic macroinvertebrates (379 Hess samples)
  - 8 orders; *N* = 115,228

UNIVERSAL TRENDS

- None across all basins.
- Swift-water specialist example below.

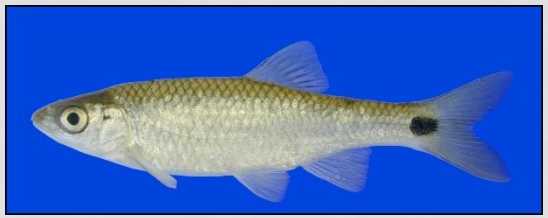




- However, with Round Two data we had sufficient replication to look at patterns among sites.

MEDINA RIVER – BANDERA AND GUADALUPE RIVER – COMFORT

- Riffles:
  - Decreases in total densities between pre-flood and post-flood
  - decreases in *Campostoma anomalum* relative abundances and densities (unexpected)
  - abundances increased for *Cyprinella venusta*
  - *Etheostoma* densities decreased (unexpected)

↑ 

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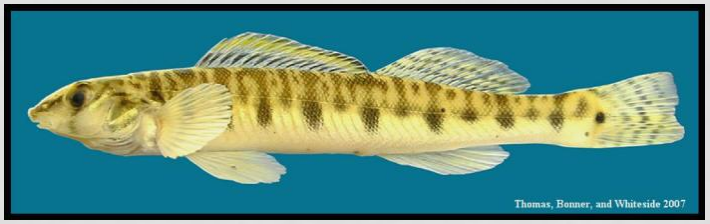
- Runs: no detectable effects

- Macroinvertebrates: no detectable effects

GUADALUPE RIVER – GONZALES AND CUERO, SAN ANTONIO RIVER – GOLIAD

- Riffles:
  - Increases in *M. marconis* densities at 1/S flood (expected)
  - Decreases in *Percina* relative abundance at 1/S flood

↑ 

↓ 

- Runs: no detectable effects
- Macroinvertebrates: Decreased densities ↓

CIBOLO CREEK – FALLS CITY

- Riffles: Relative abundances increased for *C. lutrensis* (unexpected)

↑ 

- Runs: no detectable effects

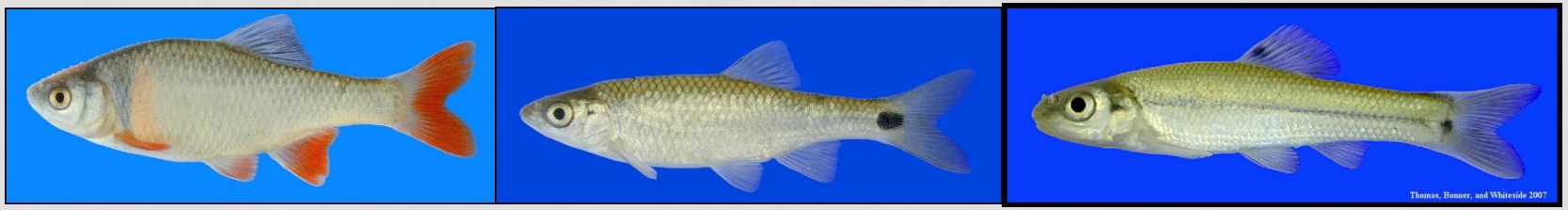
- Macroinvertebrates: Densities increased for EPT

↑ 

SAN MARCOS RIVER – LULING

- Riffles: Densities and relative abundances increased for *C. lutrensis*

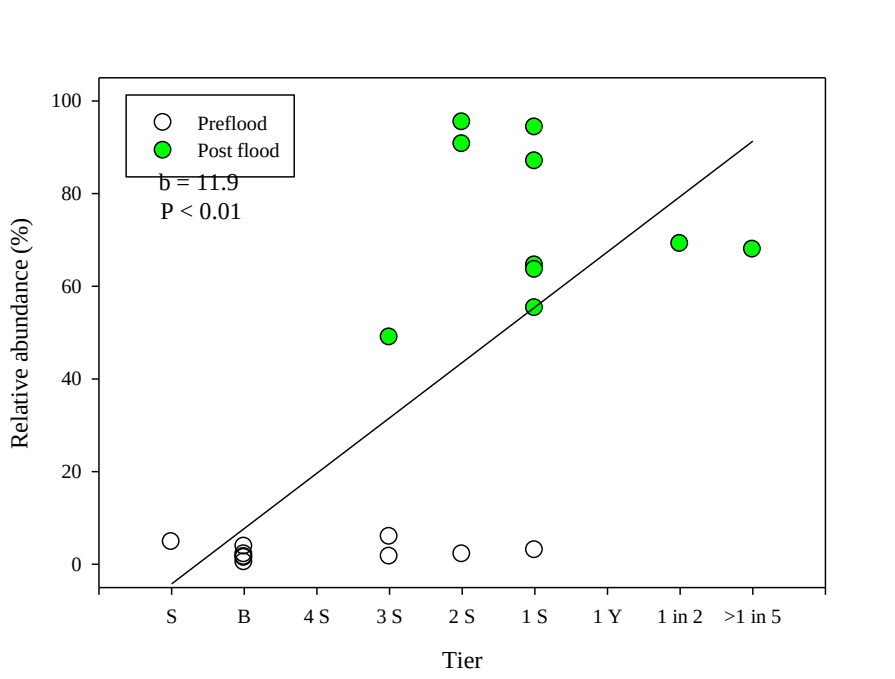
- Runs:
  - Densities and relative abundances increased for *C. lutrensis*
  - Densities increased for total fishes, *C. venusta*, and *P. vigilax*

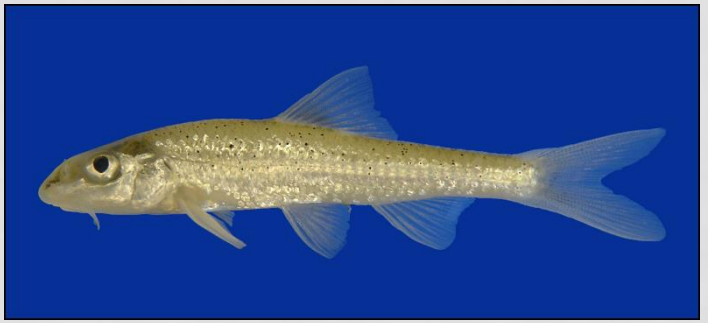


- Macroinvertebrates: no detectable effects

BRAZOS RIVER-HEMPSTEAD AND ROSHARON

- Historical fluvial fish community

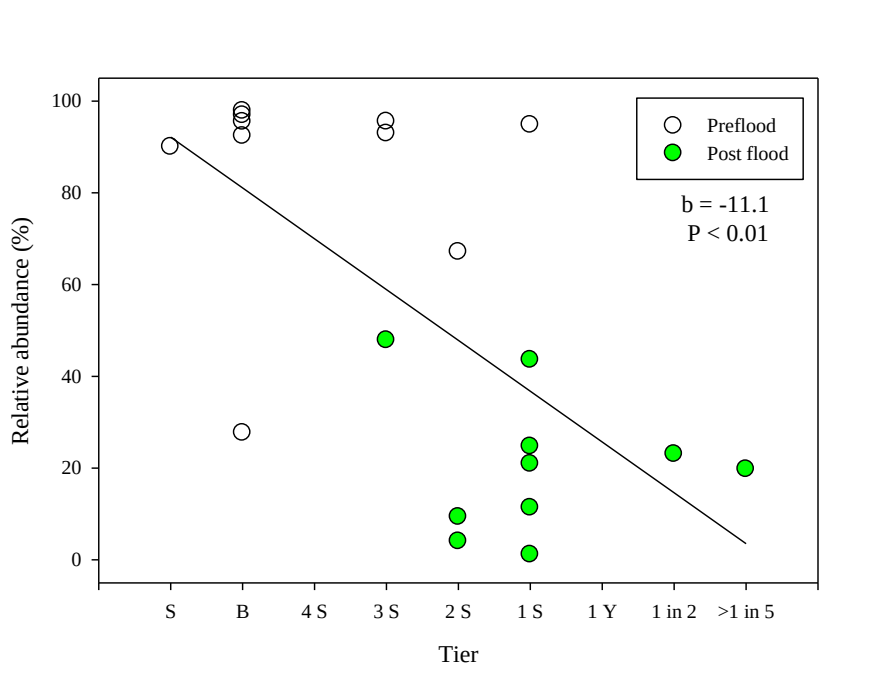


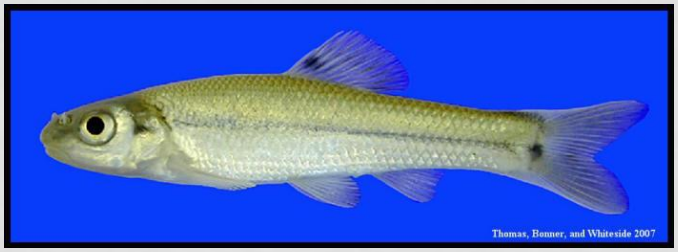


Mechanisms: Not sure, but more successful reproduction and recruitment (expected)

BRAZOS RIVER-HEMPSTEAD AND ROSHARON

- Generalist fish community
  - Historically low abundance
  - Mechanism: wash out? Failed repro and recruitment

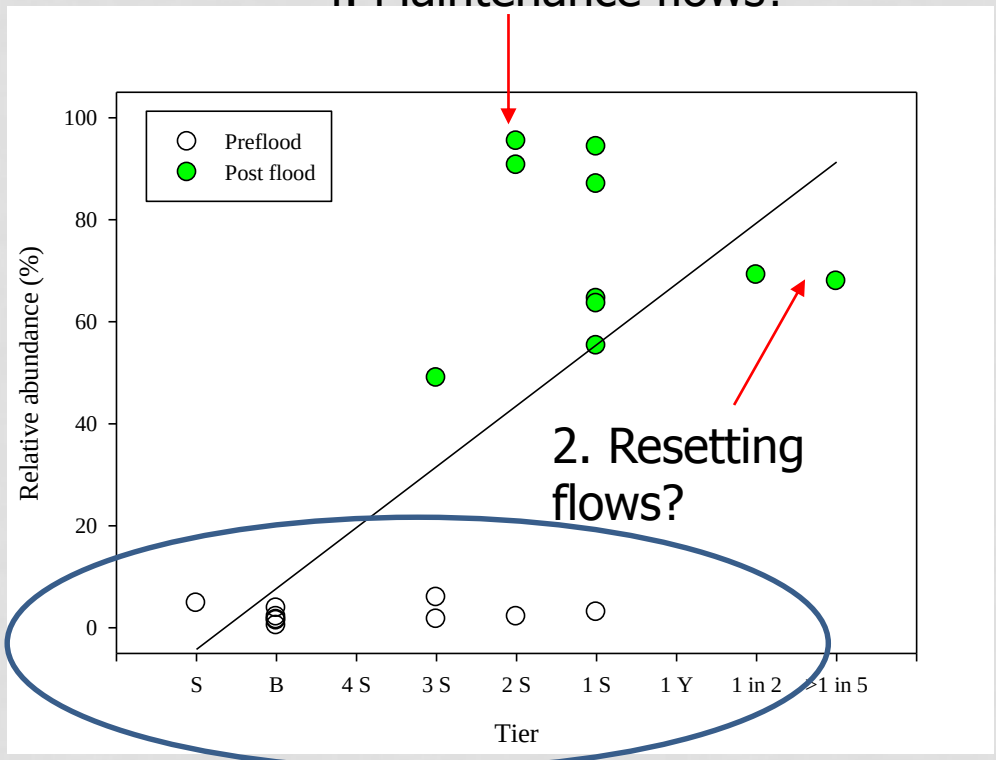


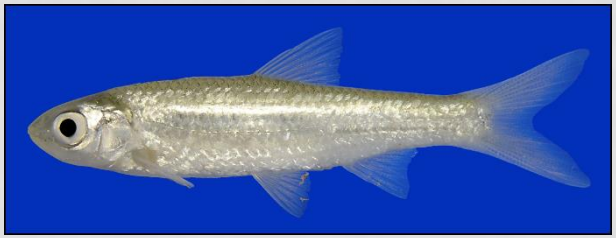


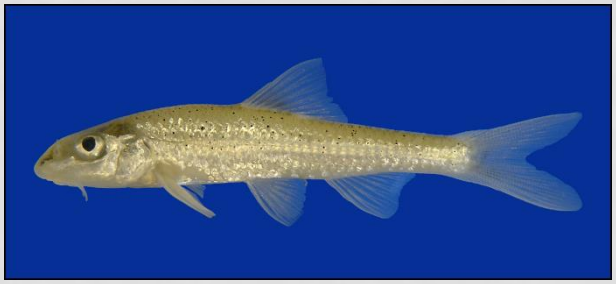
BRAZOS RIVER-HEMPSTEAD AND ROSHARON

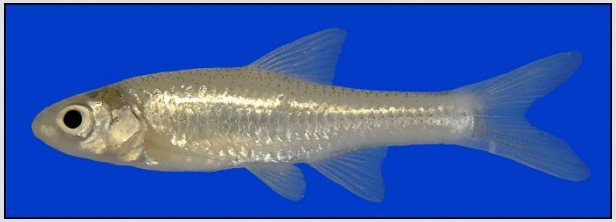
- Ecological functions of flow magnitude may be dependent on previous flow conditions

3. With resetting flows, will flow tiers have an effect?
4. Maintenance flows?









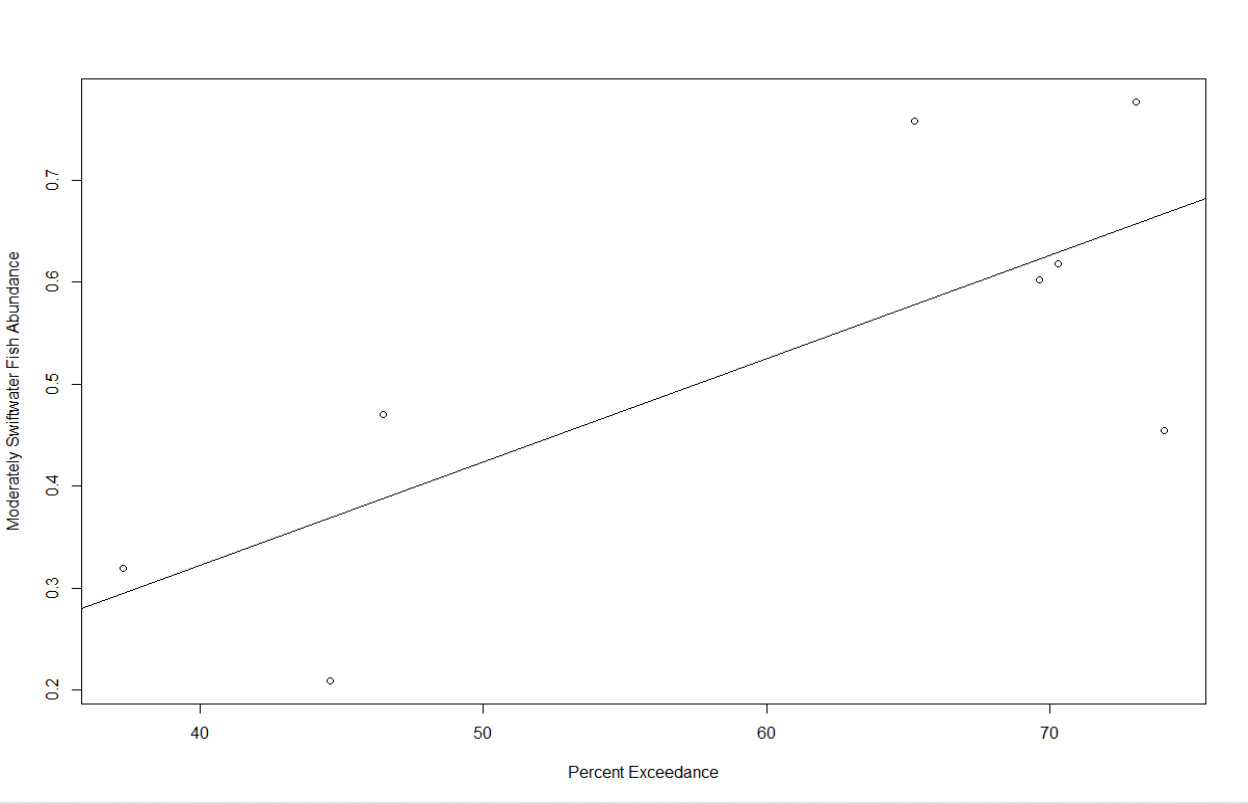
1. No effect among flow tiers

SUMMARY OF RESULTS

Combination / Individual Sites per basin	Fish and Macroinvertebrate response (Community or species)							
	4/S	3/S	2/S	1/S	1/Y	1/2Y	1/5Y	Pre-flood vs. post-flood
GSA								
Medina River—Bandera and Guadalupe River—Comfort							√	√
Guadalupe River—Gonzales and Cuero and San Antonio River—Goliad				√				
Cibolo Creek—Falls City								√
San Marcos River—Luling				√				√
Brazos								
Leon River—Gatesville and Lampasas River—Kempner								√
Little River—Little River								√
Navasota River—Easterly							√	√
Brazos River—Hempstead and Rosharon			√	√				√

HISTORICAL DATA

- 105,151 fishes
- 67 species
- Habitat
  - 55 riffles
  - 77 runs
  - 53 pools
  - 67 backwaters



- Swift-water fishes vs. flow – Colorado Basin

SAMPLING ACTIVITIES AND RESULTS

FLOODPLAIN CONNECTIVITY

- Brad Littrell

IMPORTANCE OF FLOODPLAIN CONNECTIVITY

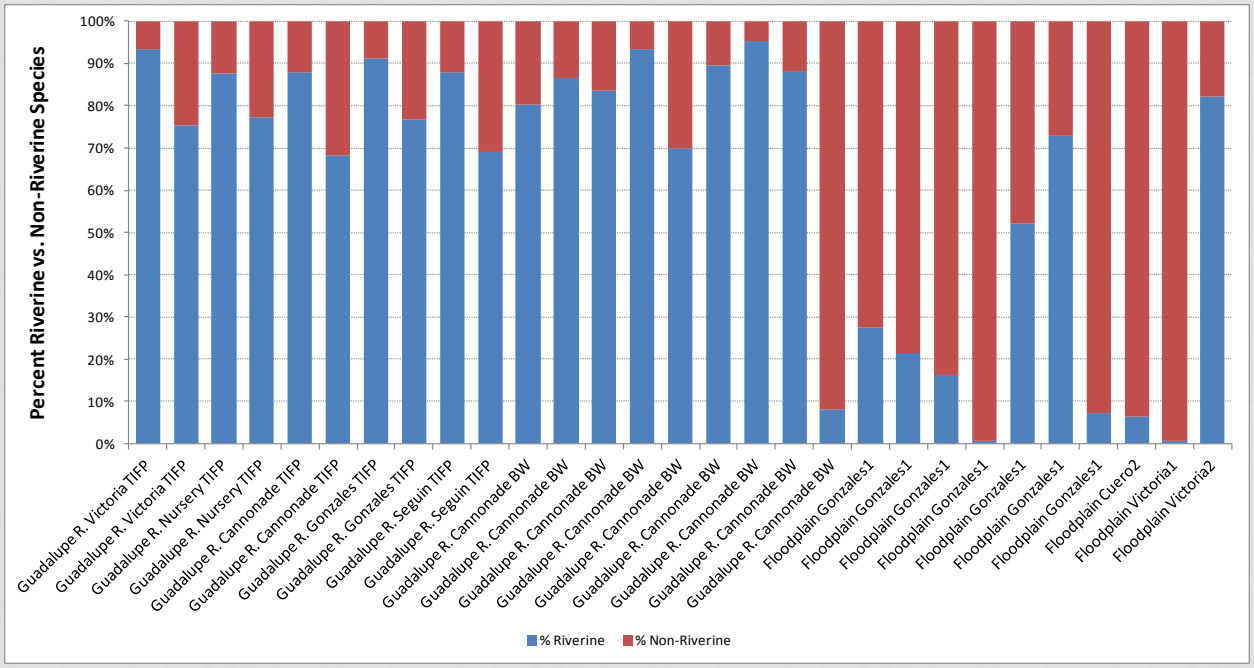
- Habitat for unique floodplain specialists
- Maintains basin-level diversity
- Provides important recruitment habitat for many species
- Source-sink dynamics
- Periodic connection is necessary to maintain water levels and allow for biotic exchange

Slough darter *Etheostoma gracile*

FLOODPLAIN SPECIALISTS

FISH COMMUNITY DATA

- Species richness ranged from 2 – 23 among floodplain collections
- Fish communities significantly different between floodplain and riverine collections



VICTORIA 2 CONNECTION POINT

- 4/1/2015 625 cfs

VICTORIA 2 CONNECTION POINT

- 2/15/2017 1730 cfs

VICTORIA 2 CONNECTION POINT

- 5/18/2017 1260 cfs

REVISED CONNECTION MAGNITUDES

Floodplain Site	Corresponding USGS Gauge	Connection Discharge (cfs)
Gonzales1	Guadalupe at Gonzales	2,822
Cuero1	Guadalupe at Cuero	1,710
Cuero2	Guadalupe at Cuero	**1,630**
Victoria1	Guadalupe at Victoria	**1,450**
Victoria2	Guadalupe at Victoria	**1,580**

SAMPLING ACTIVITIES AND RESULTS

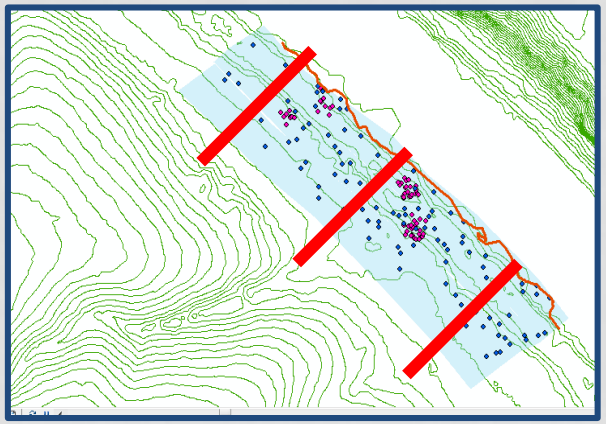
RIPARIAN

- Jacquelyn Duke

RECAP ROUND 1
TRANSECT METHOD

Riparian responses to flow:

- **Seedlings**
- **Saplings**
- **Mature trees**
- **Community**



ROUND 2 – CORRIDOR METHOD

Community:

Within Sites Community Differences:

Between Sites:

Across basins:

Recommendations:

Which method (longitudinal random vs. transects) is more beneficial for long-term monitoring?

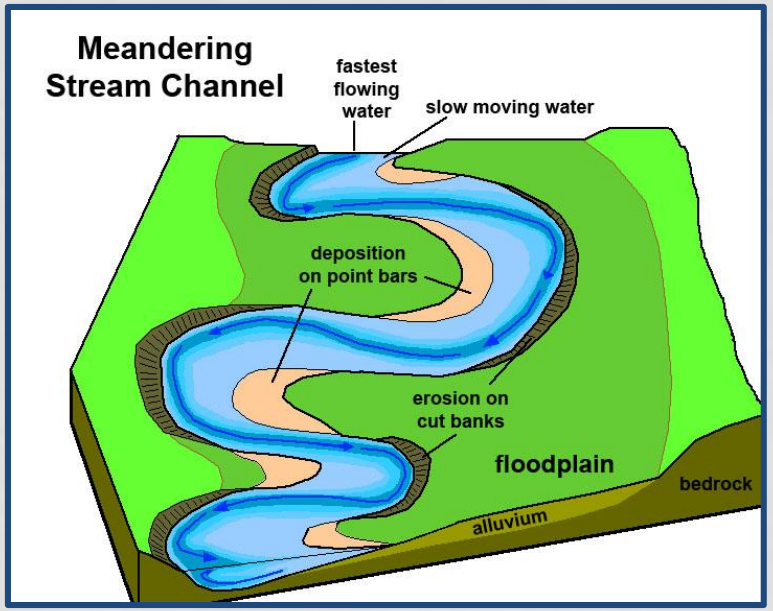
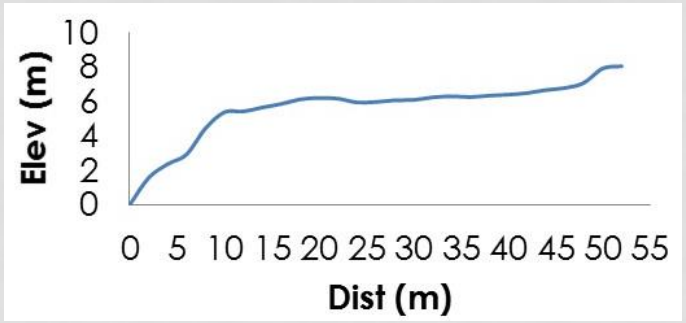


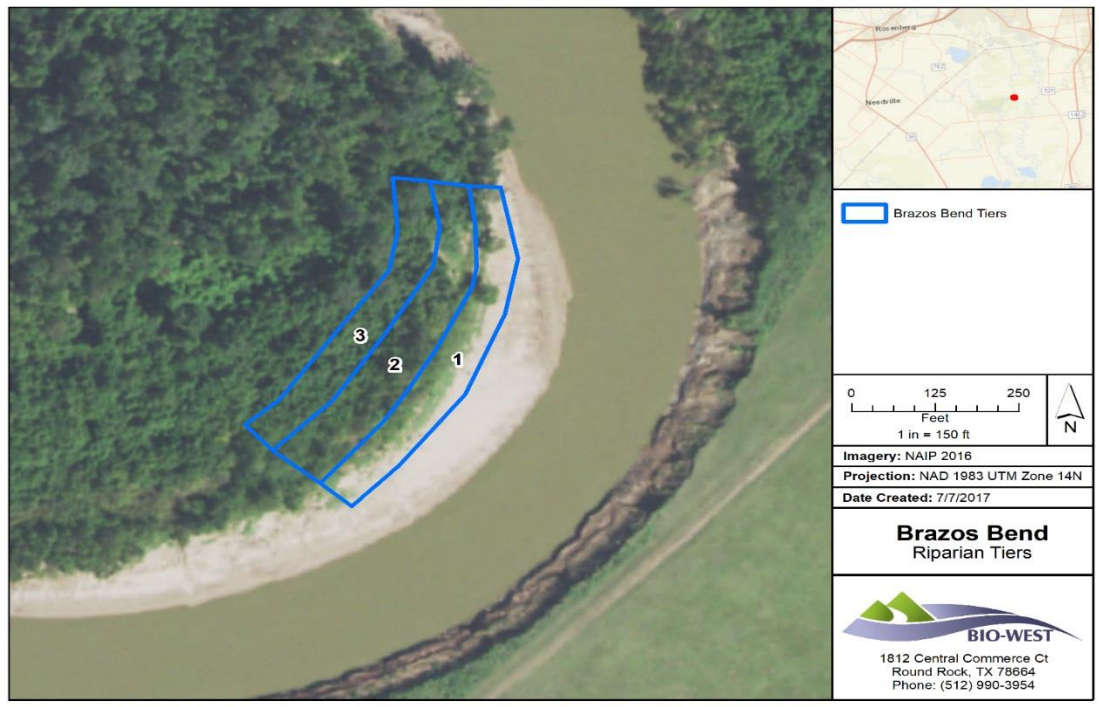
Image Credit: geologycafe.com



Site Profile

ROUND 2 - SAMPLING PROCEDURES

- Parallel tiers (lower, mid, upper)
- 2X2m random plots. Min/*tier*=25
- Woody veg counts, by size class:
  - Seedling, Sapling, Sapling older, Transition, Overstory (mature)
- Herb counts
- GPS elev. and distance to stream
- Mature tree counts and distrib



SAMPLING PROCEDURES CONTINUED

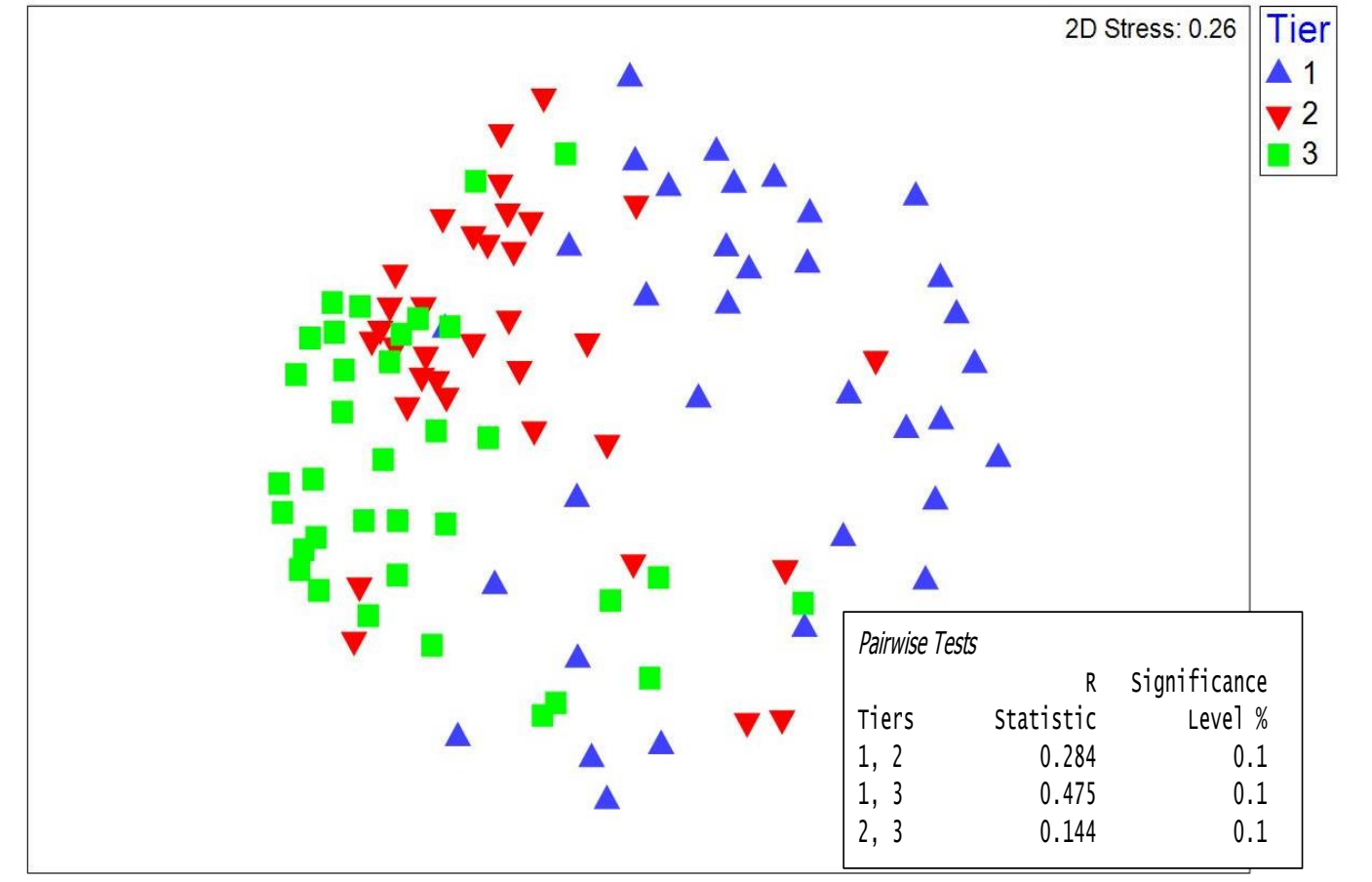
- Statistics - community differences
- USGS Gauge Data and inundation modeling
- 2 Sites: Goliad State Park and Gonzales

Photo Cred: Casey Williams

Photo Cred: Nick Castillo

RESULTS

GOLIAD – COMMUNITY ASSEMBLAGES BY TIER

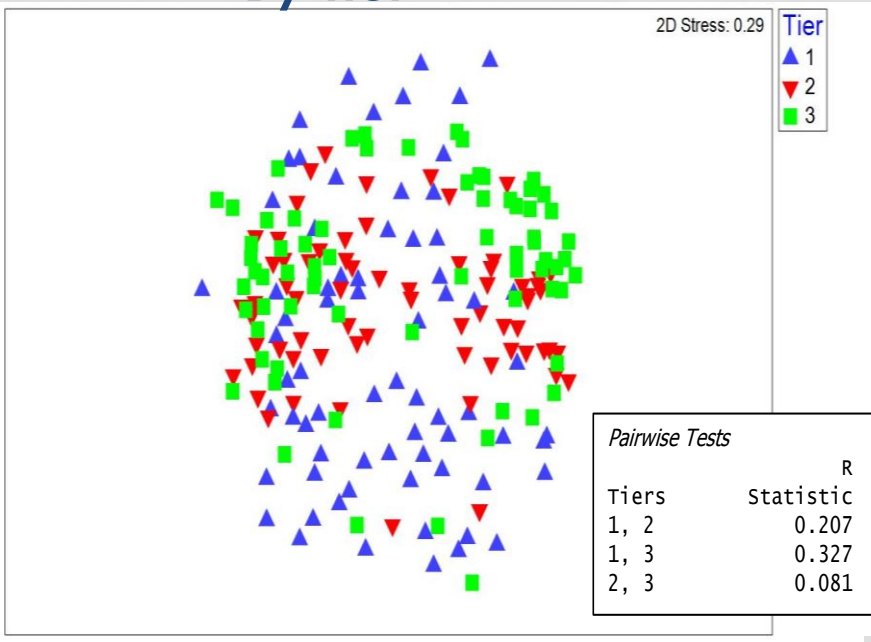


nMDS – non-metric multidimensional scaling – ordination

ANOSIM - analysis of similarities (non-parametric)

COMMUNITY ASSEMBLAGES ACROSS SITES

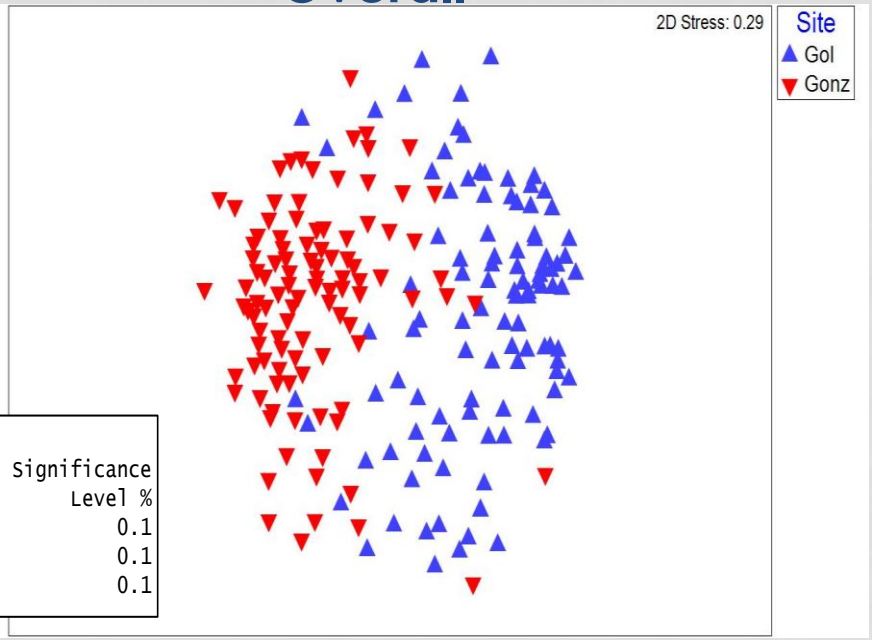
By Tier



Pairwise Tests

Tiers	R Statistic	Significance Level %
1, 2	0.207	0.1
1, 3	0.327	0.1
2, 3	0.081	0.1

Overall



Goliad

Average similarity: 28.15

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Poison ivy	1.34	8.93	0.58	31.71	31.71
Inlandseaoats	1.12	7.80	0.66	27.72	59.43
Hackberry	0.44	1.81	0.35	6.42	65.85
Purpleathflower	0.41	1.72	0.33	6.12	71.97

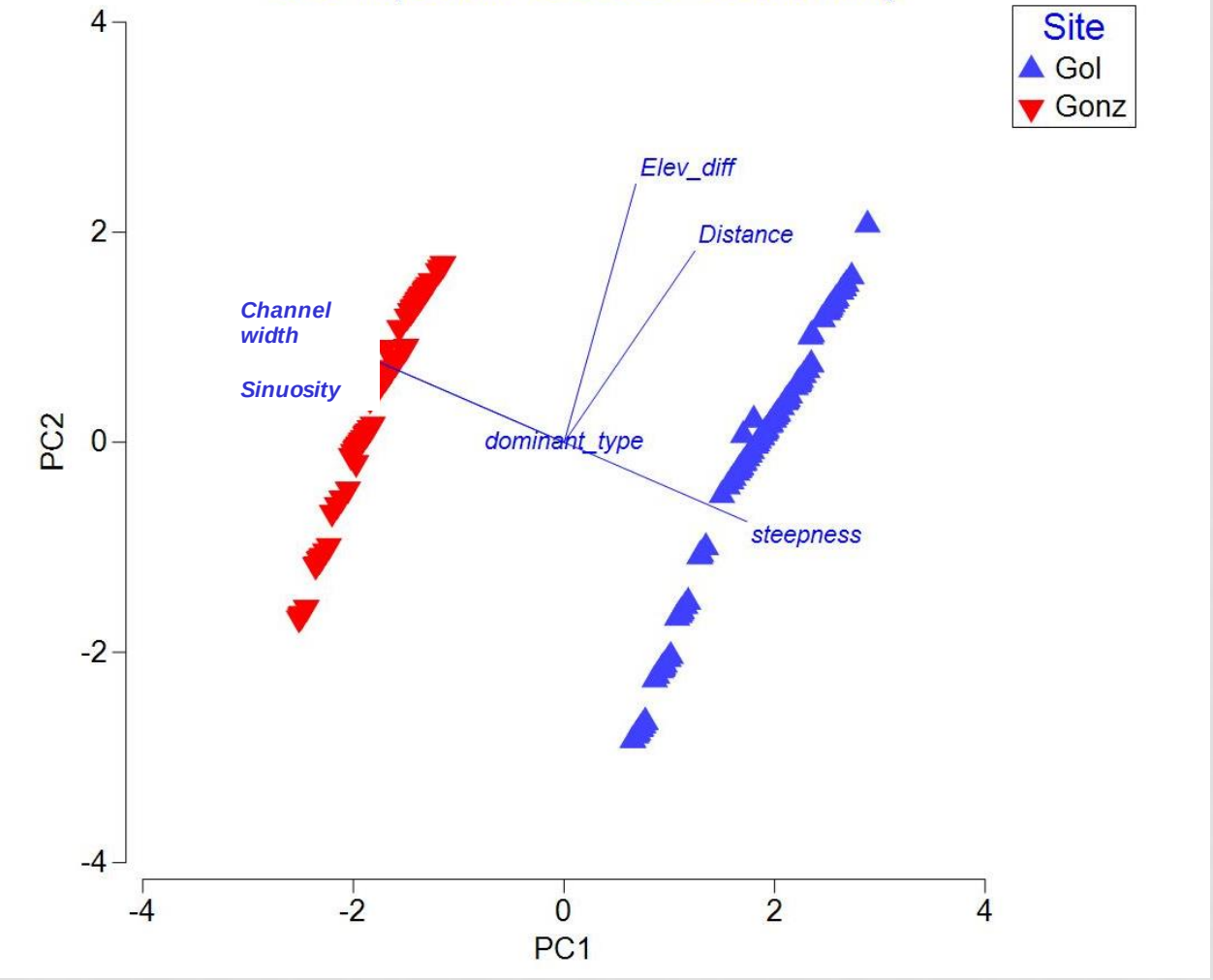
Gonzales

Average similarity: 32.56

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Giantragweed	2.22	11.20	0.99	34.41	34.41
Horse briar	1.18	5.57	0.66	17.10	51.51
Dewberry	1.04	4.71	0.69	14.47	65.99
Stickywilly	0.79	2.06	0.39	6.34	72.33

Simper – ranks species contributions to sample (dis)similarities

INFLUENCE OF ABIOTIC FACTORS



DO FLOW STANDARDS INUNDATE MATURE DISTRIBUTIONS?

Goliad	Box Elder	Green Ash	Sycamore		Full Distribution	80% of Distribution
Low Elevation (cfs)	1,669	19	19	19	19	8002
High Elevation (cfs)	10,021	6,380	19	639	10,021	

Gauge Location	Study Site	Season / Time Period	Subsistence (cfs)	Hydrologic Condition	Base (cfs)	Small Season Pulse (cfs)	Large Seasc Pulse (cfs)
Goliad	Goliad	Winter	60	Dry	200	1520	N/A
		Winter	N/A	Avg	329	1520	N/A
		Winter	N/A	Wet	469	1520	N/A
		Spring	60	Dry	174	1570	
		Spring	N/A	Avg	313	1570	
		Spring	N/A	Wet	502	1570	
		Summer	60	Dry	139	1640	
		Summer	N/A	Avg	237	1640	
		Summer	N/A	Wet	481	1640	
		Fall	60	Dry	481	2320	
		Fall	N/A	Avg	280	2320	
		Fall	N/A	Wet	584	2320	
		Aril - June (3 per)					4000
		Feb -April (2 per)					4000
		July-Nov (2 per)					8000

CONCLUSION

- Combining the two methods enhances each
- TCEQ flow standards are inconsistent in meeting riparian needs
- Further studies should span the growing season

ENVIRONMENTAL FLOWS VALIDATION METHODOLOGY

APPLICATION

- Ed Oborny

STUDY CONCLUSIONS

- Aquatics
  - Fish and macroinvertebrates are:
    - Good ecological indicators for water quality and aquatic habitat for evaluating subsistence and base flows.
    - Ecological indicators for pulse flows within the range of the TCEQ flow standards inconclusive. (*Exceptions – 1 per season events*)
  - Major flood events shape the aquatic community.
    - Follow up monitoring after major shifts might serve as the ecological linkage of fish and macroinvertebrates to smaller pulses.

STUDY CONCLUSIONS

- Floodplain Connectivity
  - Strong ecological indicator relative to pulse flows, water quality.
  - Most recent floodplain features connected with existing TCEQ flow standards in the GSA Basin.
- Riparian
  - Strong ecological indicator relative to pulse flows.
  - Larger pulses than established TCEQ flow standards are generally needed to support the existing riparian communities.

ENVIRONMENTAL FLOWS VALIDATION METHODOLOGY

- Two main objectives
  - To inform and refine validation methodologies with the goal of having a scientifically defensible approach for testing TCEQ environmental flow standards.
  - To provide the BBASC with information on how application of these methodologies might validate or suggest refinement for existing TCEQ flow standards at select basin sites.

ENVIRONMENTAL FLOWS
PROPOSED VALIDATION METHODOLOGY

- Standardized approach
- Incorporates multiple ecological components
  - **Level I – Aquatics**
  - **Level II – Floodplain Connectivity**
  - **Level III – Riparian**
- Simplified desktop and field activities

ENVIRONMENTAL FLOWS
PROPOSED VALIDATION METHODOLOGY

Level 1: Aquatics

- ***A. Question:*** Does the study reach have important aquatic resources (native fish communities, endangered or threatened species, recreational or commercial fisheries, unique instream habitats, etc.) and if so, what is the BBASC goal for maintaining the current assemblage and community composition?

- ***B. Decision/Goal:*** If "yes," and a goal* is established, then proceed with the subsistence and base-flow recommended aquatic evaluation (C). If "no," do not consider aquatics in the validation evaluation.

- ***C. Flow Evaluation:*** Based on the results of this study, fish and macroinvertebrate community data could be compared to the pre-established goal and a direct comparison made. If certain sites do not have recent seasonal biological data, then an on-site aquatic evaluation would consist of a field-sampling effort.

- ***D. Long-term monitoring recommendation:*** Based on the results of the evaluation and potential of future projects affecting this site, determine whether a seasonal, long-term monitoring of the aquatic community is warranted for future adaptive management decision making.

ENVIRONMENTAL FLOWS
PROPOSED VALIDATION METHODOLOGY

HYPOTHETICAL GOALS

- ***Aquatics:*** Fish community density and relative abundance will be maintained within 25% of the existing native fish community structure as represented by data collected in a rolling 10-year period leading up to the present time.

- ***Floodplain Connectivity:*** Recent downstream oxbows are important to support the fisheries community and a minimum of 75% of recent downstream oxbows should be connected in the spring and fall for a minimum period of two consecutive days.

- ***Riparian:*** 80% of the existing riparian community at the site is inundated in the spring and fall for a minimum duration of 3–4 days.

ENVIRONMENTAL FLOWS
FLOW EVALUATION – *SAN ANTONIO RIVER AT GOLIAD*

Level 1 - Aquatics: Subsistence, Base and Pulse Flows:

- ***Standards:*** Seasonal TCEQ subsistence and base recommendations are 60 cfs, and 139 to 584 cfs, respectively. Seasonal TCEQ small pulses range from 1,520 to 2,320 cfs, which essentially conform to the 1 per season recommendations from the BBEST.
- ***Assessment:*** Biological sampling conducted via this study shows that the fish community within this study reach is within the hypothetical 25% goal compared to data collected over the past 10 years. A 1-per-season events trigger an ecological response for fish and macroinvertebrates.

ENVIRONMENTAL FLOWS
FLOW EVALUATION – *SAN ANTONIO RIVER AT GOLIAD*

Level 1 - Aquatics: Subsistence, Base and Pulse Flows:

- Adaptive management ***considerations***:
  - *Subsistence:* There is nothing in the existing dataset that warrants a consideration for adjusting subsistence flows in either direction at this time.
  - *Base:* There is nothing in the existing dataset that warrants a consideration for adjusting base flows in either direction at this time.
  - Pulse Flows:
    - Maintain TCEQ small seasonal pulses for winter, summer, and fall because they correspond to the magnitude of BBEST 1-per-season events linked to fish and macroinvertebrate ecological response.
    - Change the TCEQ small seasonal pulses (equivalent to BBEST 2-per-season events to a magnitude equivalent to the BBEST 1-per-season event. This would require:
      - Increasing the TCEQ small seasonal pulse for spring from 1,570 cfs to 3,540 cfs to be consistent with the magnitude of BBEST 1-per-season event.
      - Decreasing the frequency of TCEQ small seasonal pulse for spring to one event for consistency with other 1-per-season events at this site.

ENVIRONMENTAL FLOWS
FLOW EVALUATION – *SAN ANTONIO RIVER AT GOLIAD*

Level 2 (Floodplain Connectivity): Pulse Flows

- ***Standards:*** TCEQ small pulses range from 1,520 to 2,320 cfs and large season pulses from 4,000 to 8,000 cfs.
- ***Assessment:*** Biological sampling conducted via this study show that to connect the recent floodplain feature downstream of the study site a discharge of 2,740 cfs is needed.

- Adaptive management ***considerations***:
  - There are no adjustments to the large seasonal pulses as they meet the floodplain connectivity goals and are required to meet the Level 3 riparian goals (next level).
  - Eliminate small TCEQ seasonal pulses as none of them connect this floodplain feature.
  - Increase the spring and fall small TCEQ pulses from 1,570 and 2,320 cfs to 2,750 cfs in order for them to provide floodplain connectivity.
  - If small spring and fall pulses are increased, consider decreasing the TCEQ standards durations of 16 and 19 days, respectively to 3 or 4 days. Shorter durations have proven sufficient ecologically to support this ecological linkage.

ENVIRONMENTAL FLOWS
FLOW EVALUATION – *SAN ANTONIO RIVER AT GOLIAD*

Level 3 (Riparian): Pulse Flows

- ***Standards:*** Seasonal TCEQ small pulses range from 1,520 to 2,320 cfs and large season pulses from 4,000 to 8,000 cfs.
- ***Assessment:*** Riparian sampling conducted via this study shows that to inundate 80% of the existing riparian community approximately 8,000 cfs is needed seasonally.

- Adaptive management ***considerations***:
  - *Pulse flows:*
    - Increase the TCEQ large seasonal pulse for spring from 4,000 cfs to 8,000 cfs to meet the hypothetical goal.
    - Eliminate all small TCEQ seasonal pulses at this location because they inundate a limited area of or no riparian habitat. Note: this choice contradicts a Level 1 aquatics potential recommendation.

ENVIRONMENTAL FLOWS
FLOW EVALUATION – *GUADALUPE RIVER AT GONZALES*

Level 3 (Riparian): Pulse Flows

- ***Standards:*** Seasonal TCEQ small pulses is 950–3,250 cfs and large season pulses are 1,760–4,154 cfs.
- ***Assessment:*** Riparian sampling conducted via this study shows that to inundate 80% of the existing riparian community approximately 6,800 cfs is needed.

- Adaptive management ***considerations***:
  - *Pulse flows:*
    - Increase the spring and fall TCEQ large-pulse standards each from 4,154 to 6,800 cfs.
    - Consider decreasing the duration of days listed in the spring and fall large-pulse standards.
      - Ecological data collected during this riparian study have shown a solid seed dispersal and wetting effect with inundation from 3 to 4 days. The current TCEQ standards' large spring and fall pulses have durations of 24 and 23 days, respectively. These durations may not be supportive of either dispersal or wetting with the possible reverse effect of drowning out seedlings and saplings.
    - Eliminate winter and/or summer small TCEQ seasonal pulses as they inundate limited to no riparian habitat.

ENVIRONMENTAL FLOWS
AVAILABLE DATA * from this study

GSA SB 3 TCEQ Environmental Flow Standard Sites	Level 1 Aquatics	Level 2 Floodplain Connectivity	Level 3 Riparian
Guadalupe River—Comfort	√		
Guadalupe River—Spring Branch			√
Blanco River—Wimberley			√
San Marcos River—Luling	√		
Plum Creek—Luling			
Guadalupe River—Gonzales	√	√	√
Sandies Creek—Westhoff			
Guadalupe River—Cuero	√	√	
Guadalupe River—Victoria	√	√	
Medina River—Bandera	√		
Medina River—San Antonio			√
San Antonio River—Elmendorf	√		√
San Antonio River—Falls City	√		√
Cibolo Creek—Falls City	√		√
San Antonio River—Goliad	√	√	√
Mission River—Refugio			

- Does not preclude an assessment of these other sites by the BBASC.
- Recent biological data from other sources could just as easily serve to inform Level 1 (Aquatics) assessments at locations not covered by this study.
- Secondly, each level has desktop and field assessments designed to take minimal effort to inform the completion of this approach for Level 2 and 3.

ENVIRONMENTAL FLOWS
FUTURE RESEARCH AND MONITORING RECOMMENDATIONS

- SB3 Applied Research
  - Post flood community shift aquatics
  - Freshwater mussels
  - Channel morphology
- Long-term Monitoring
  - Each component – flow driven
    - Select sites in each basin

QUESTIONS / COMMENTS?

- Acknowledgements
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  - SARA / River Authorities
  - BBASC and BBEST
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